Power Quality and Stability Improvement for optimal EV charging using Grid and PV System

SHORT SYNOPSIS

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by

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Certificate

I hereby declare that the short synopsis "**Power Quality and Stability Improvement for optimal EV charging using grid and PV System**" is being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Electrical & Electronics Engineering under Faculty of Engineering and Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2022-23

It is a bona fide record of original work carried out under the supervision of Dr. Anita Khosla, Professor, Dept. of Electrical & Electronics Engineering and has not been submitted in full or part to any other university or institute for the degree. Further, it is certified that the short synopsis is plagiarism-free and the proof has been submitted.

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ABSTRACT

Currently, the modern world switches over to electric vehicles (EV) owing to the environmental hazards in fossil fuels. The EV are influence on the battery operation that is energized by power-generating units. The solar photovoltaic (SPV) system is one of the most promising renewable energy sources for future power generation systems. SPV-connected EV charging is an emerging technology due to the reduction of cost and emissions. However, several factors must be considered while interacting with the SPV with the EV. One of the important issues in SPV is power shortage due to the cyclical disparities in solar irradiance. In order to meet the power requirement from the EV, the maximum power point tracking (MPPT) controllers are adopted with the SPV. The integration of EV chargers with the SPV and grid has brought some impacts on the system such as an increment in reactive power and power losses. Due to these impacts, the power system stability will be reduced, it also affects the power flow to the EV system. On the other hand, the excess power generation from the photovoltaic model may increase the voltage issues in the EV. Thus, the power supply to the EV is controlled by the battery management system (BMS). The modelling of efficient controllers for battery control will reduce the power unbalancing in the EV system. Moreover, the power flow can be controlled by meta-heuristic algorithms. Furthermore, the integration of EV in the distribution system injects the harmonics in the system hence, the power quality (PQ) gets reduced. The impacts of improper battery scheduling, unbalanced power flow and lower system stability affect the PQ of the system. On the other hand, reactive power compensation is an important area for improving the power flow as well as PQ in the grid-connected system. By concerning all these factors, this research has proposed different approaches to adopt with the different system conditions. This research will bring an effective way to enhance power generation and an optimum solution to feed the EV based on its requirement.

Keywords: Electric Vehicle, EV Charging Station, EV Charger, Smart Grid, Photovoltaic, PV, Grid, Power Quality

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1. INTRODUCTION

The transport sector is essential to emitting harmful gases into the environment owing to fossil fuels. To cater for the issues in CO2 emission, the transport sectors are switching over to battery-operated, also this is becoming our future need as we couldn't oversee the fossil fuel crisis coming day by day (Wahedi and Bicer 2020). The adoption of EVs will minimize the need for fossil fuels and the associated energy depletion. In recent years, the inclusion of renewable energy sources (RES) with electric vehicles (EVs) has gained more attention to solve the energy crisis and demand. In this study, we came to know also that the backup system (such as Battery Bank) should be scheduled well so that better utilization of resources can be done. In some cases, EV charging stations are attached to the distribution network to supply the energy from RES (Mehrjerdi and Hemmati 2020). Multiple sources are connected with the EV to charge the numerous EVs, whereas the EV's characteristics differ by type. However, EV charging strategies must also consider the cost of electric energy, peak shaving load function also can mitigate lots of issues related to the performance (Sbordone, Bertini, Pietra, Falvo, Genovese, Martirano 2015). The EVs are powered by onboard energy storage systems (ESS) equipped with several storage devices, as today's scenarios focus on onboard storage as seeking the day & night EV charging time. Our life is as fast as we work 24 hours so there is no time barrier which creates the most significant use of storage systems in many ways (Weitzel and Glock 2018). Because of its low cost and high energy density, battery ESS is used in many EVs. State of charge (SOC) is an important factor in examining the battery operation that denotes the power availability in the battery, also study says swapping stations is a low-cost solution than charging lanes and charging stations as showing factor power availability. The SOC of the battery is decreased while the EV is operating, so it is necessary to charge the battery to ensure continuous operation (Chen, Yin, and Song 2018).

Power quality (PQ) is an important consideration in grid-connected charging stations. However, the non-linear nature of EV chargers introduces harmonics into the system, also efficiency improves and is more stable in the dynamic stage in case of a direct connected DC storage supply in place of AC from the grid directly (Sharma, Sood, Alam, Shariff 2020). The PQ issues in EVs also affect the equipment in the distribution network during cloud transients it's having rapid fluctuations. On the other hand, during day time when SPV is available than EV is directly connected to the solar system, the penetration of SPV in EVs will cause fluctuations in solar irradiance, thereby resulting in poor PQ. Integration

may be economical as well as beneficial to the environment but there are many adverse effects in the integration related to PQ & voltage deviation including network loading (Tran, Islam, Muttaqi, Sutanto, 2019; Nasr Esfahani, Darwish and Williams, 2022; Khan, Ahmad, Ahmad, Saad Alam, 2018). Converters play an important role in SPV-connected EV charging to deliver the power from SPV to the EV, which controllers control. The unidirectional and bi-directional converters have played a crucial role in delivering power to the EV, although it depends upon which topology we used to connect power to EV (Nasr Esfahani, Darwish and Williams 2022). The battery charging in EV applications is divided based on the charger used: on-board & off-board are two types; the former is used for slow charging and the latter provides quick charging (Khan, Ahmad, Ahmad, Saad Alam 2018). The charging duration of EVs is a vital consideration for the customer due to cost constraints.

Solar photovoltaic (SPV) is considered an effective energy option that has gained more attention in the EV application. However, power generated from SPV may suffer from the intermittent nature of solar irradiance (Badawy and Sozer 2017; Mohamed O. Badawy and Yilmaz Sozer 2015). Only the SPV is not sufficient to feed the EV due to its inconsistent power generation as the limited time of availability of irradiation during the day with an average of 5hours approximately. To alleviate such difficulties, maximum power point tracking (MPPT) controllers are used (Hassoune, Khafallah, Mesbahi, Benaaouinate, Bouragba 2018). The MPPT controller maximizes the power from the SPV to improve power storage and also helps to control the required input for the controllers/inverters.

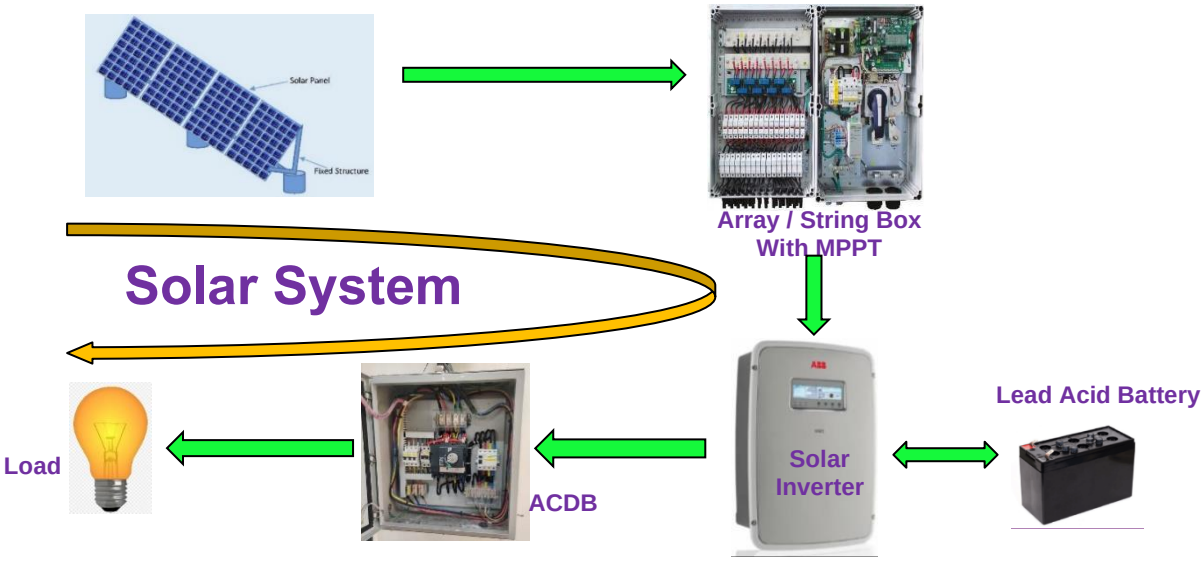

Figure 1: Typical SPV System (Source:Self)

Moreover, the load required by EV also varies with time, which leads to poor stability because during the evening time most of the EV comes in line which leads to poor load shaving as well as a very adverse effect on the whole system. Thus, the charging as well as discharging control strategies are provided for the controller to tackle this situation (Mumtaz, Ali, Ahmad, Khan, Hassan, Kamal 2017). The control strategies minimize the peak demand and cost while improving frequency regulation with harmonic distortion. Hence, there are several methods that the authors have developed to overcome these issues (Rahbari, Vafaeipour, Omar, Rosen, Hegazy, Timmermans, Heibati, Bossche 2017).

Most of the literature on fuzzy logic (FL) based controllers is adopted to improve batteries' charging and discharge. In such methods, the FL is applied to take control measures by SOC of the battery in three stages named nominal, low and high SOC (Garcia-Trivino, Torreglosa, Fernández-Ramírez, Jurado 2018). Additionally, the proportional-integral (PI) is used along with FL for the converters to improve the system stability as overshoot can better control by Fl and a large quantity of binary stable data can proceed faster in PI (Sayed and Gabbar 2016).

From the view of PQ, EV should minimize the harmonics to improve the PQ. The issues in PQ are also solved by applying an efficient methodology for grid interfacing. Applying the FL in the system study shows that the RMS value in the Hz deviation by 74% which is a high amount of improvement and directly intact to the PQ in the system (Falahati, Taher, and Shahidehpour 2018). Recently, ANN based FL have been operated to enhance the communication between vehicles & the grid (V2G), which is a primary concern for the integration of the grid with EVs. Data capturing will help for better decision-making & also can trap the fault situation very efficiently (Sah, Kumar, Bose 2020).

In recent years, optimized fuzzy controllers have been applied to reduce the losses and fluctuations in power transmission & also in high tie-line the negative impact improvised effectively in power flow, although many other techniques used in many studies FL system is widely used because it is any most power extended hand which leads the whole system towards AI for next generation system demand (Said, Ali, Hartmann 2020).

This research proposes efficient methods for improving power flow in respect of power quality improvisation from the grid to EV charging stations and similarly from SPV (Solar Photovoltaic) to EV charging stations. Seeking in the view of power availability, also considered better battery scheduling to enhance the stability in the system and Power Quality taken as the main focus with the help of STATCOM in the system of SPV-assisted EV charging as well as in the system of grid-connected EV charging stations.

2. LITERATURE REVIEW

Irfan, Rangarajan, Collins, Senjyu (2021) proposed a controller for an adaptive neuro-fuzzy interface system (ANFIS) to improve PQ in grid-connected EV. The incremental conductance (IC) MPPT controller was used for extracting maximum power from SPV. The D-STATCOM was added to the system to enhance the reactive power compensation, which was connected to the capacitor on the DC side. The proposed ANFIS controller generated the switching pulses for DSTATCOM. The instantaneous reactive power theory was applied to produce the reference current that was equated with the actual current. The study shows a clear comparison between three types of controllers PI, ISCT and ANFIS, in this ANFIS reduces the source current THD %age in comparison to PI & ISCT by 45% and 36% respectively as well as reduces the load current THD %age by 14% and 22% respectively. Moreover, the proposed model was investigated under balanced and unbalanced conditions, reducing the THD of the current.

Prem, Sivaraman, Suriya Raj, Sathik, Almakhles (2020) proposed a control algorithm for rapid charging and a converter model to take control actions in grid-connected EVs. In that proposed model, the T-source impedance network produces a large gain with galvanic isolation. The switching algorithm was used for controlling the bi-directional T-source DC-DC converter. The system response was improved by using the state space average model. In that model, the charging rate was controlled by a T-source impedance network and the system comply with the international standard IEC 61000-3-2 which states that the low I/P current THD.

Wang, Ali Abdalla (2022) proposed the Jaya optimization algorithm-based EMS in SPV-assisted EV. The grid's installation cost and revenue were considered objective functions in such a method. Moreover, the performance of the battery and the EV charge were considered for taking the controlling measures. Power balancing was measured between the RES, grid, energy storage system, and household. After that, the power exchange constraints were considered for the efficient operation of the battery. The optimization algorithm formulated power flow constraints as an objective function. This study, it shows that the proposed algorithm Jaya & PSO saved a lot in energy consumption which is 54% and 51% respectively in comparison to without any algorithm in the system. Although in summer, shaving also increases by 15% from the winder saving.

Sigalo, Pillai, Das, Abusara (2021) proposed mixed-integer linear programming (MILP) for battery ESS. To get previous information, long-short memory (LSTM) was

used in that system. In addition, the receding horizon strategy was applied to minimize the prediction error in the EMS. The LSTM was updated with real-time data, and the battery commands were applied in real-time. The proposed method was evaluated with the existing approaches based on the benchmark data. The MILP meets the energy demand by considering the power from the battery, the grid and demand to optimize the cost function. Real-time monitoring will help the system to meet the benchmark with 1.252% as the closeness percentage to achieve the desired target.

Mohamed, El-Sayed, Metwally, Selem (2020) proposed the salp swarm optimization algorithm (SSA) based controller for optimizing the voltage and current control parameters. That optimized model minimizes fluctuations in DC-bus voltage by matching the active as well as reactive power to the grid. The MPPT controller improved power from SPV. In that model, the voltage source inverter (VSI) was linearized for modelling linear feedback control. The transfer function was modelled by an average switched model, whereas the park transformation was applied for the d-q transformation. The SSA tunes gains of the proportional-integral (PI) controller via minimum mean square error (MSE). SSA-based controllers are very useful in THD applications compared to analytical one and 50% error can minimize in the same comparison by SSA in DC bus voltage.

Khan, Ahmad, and Alam (2019) suggested a novel strategy to develop the PQ in grid-assisted SPV-tied EV. In that model, each EV's control was applied individually to regulate the power transfer from the DC bus to the grid. The converter was controlled by a PI voltage control that produces a reference current by the power input. The charger controller carries the constant current-constant voltage (CC-CV) charging scheme. In the CC-CV, the current in the battery was maintained constant, and the voltage increased to the pre-defined value. Similarly, the voltage was kept constant then the current was raised to a pre-defined value in constant current mode.

Petrusic and Janjic (2020) proposed a multi-criteria optimization approach for controlling charging and discharging in an EV-connected grid. The study empathized with the multi-sources connection to the battery to make a topology to make more availability of EV charging time because if any one source is ideal that will act like a buffer which is available on the own time. In that proposed method, the energy obtained from the SPV and battery was estimated by examining the amount of energy delivered to the EV. The lithium-ion storage system designed the degradation model of the battery. The maximum power generation from SPV, the battery's ageing, and the battery's price were considered the

objective functions of the optimization algorithm. Moreover, the power from the battery, grid, and SPV was formulated as constraints for the power flow management.

Wu, Zhang, Ravey, Chrenko, Miraoui (2020) proposed a Markov decision process-based control strategy for battery scheduling in the grid-assisted EV charger. That model works on vehicle-to-grid (V2G), to improve the auxiliary service. In addition, the adapted bounded real-time dynamic programming (BRTDP) algorithm was used to enhance the model's efficiency. That BRTDP expresses the subset of the state space model that provides the MDP solution. In that approach, the problems were formulated based on the cost function and the states were represented based on the SOC of the battery. In the study, the comparison shows that the cost reduction achieves 55% & 29% in summer and winter respectively, and also states higher computational efficiency when it is compared to the conventional dynamic programming algorithm. So it will become practical and scalable.

Ali, Mahmoud, Lehtonen (2021) proposed an efficient method for the optimum operation of grid-connected EV charging. In that model, the deviation in voltage and tie-line power were considered objective functions. The Grey-Wolf optimization algorithm was used for optimizing the objective functions. The non-dominated sorting technique generated the Pareto optimal ranking. Initially, the microgrid and RES data were examined to model the RES and demand probabilistic model. The planning problem of the optimization algorithm was solved in the second phase. Both outer-level and inner-level control operations were solved by objective functions of deviated voltage and tie-line power. Finally, the controllers' optimum size and location were obtained at a minimum cost. In the study, 57% reduction in voltage deviation and 81% reduction in tie-line power, it’s on the higher side of significant value if we are going to compare approaches which were adopted in these scenarios in past.

Shahab, Wang, and Junejo (2021) proposed a control strategy for three-phase grid-assisted EVs. The control algorithm offers an optimum power factor regulation by considering the different operating modes of the system. The control algorithm was applied to examine the reference voltage and current for the inverter. The microgrid management algorithm was used to incorporate different modes of operation into the system based on the user's requirements. The control algorithm measures input data for each time sample to take necessary actions. The study gives the next proposed solution that can be applied to the stationary battery also and a reduction in regulation can be taken as the next step in voltage & frequencies.

3. PROBLEM FORMULATION AND MOTIVATION

The PQ and stability issues in distribution generation connected non-linear load characteristics of the EV increase EV charging stations. Many blackouts have occurred in the system due to poor system stability and higher stress. In addition, the integration of EVs with the grid caused uncertainties in the system through the varying load demand. In most of the existing work, the stability issues are studied only on the side of power system transmission. Since the varying load demanded by the EV causes a reduction in system stability. In the view of grid-connected charging stations, the improper integration of SPV results in poor stability. The integration of the grid with the SPV can be improved by adding an efficient controller.

Moreover, the integration of EV in the distribution system injects the harmonics into the system; hence, the PQ is reduced. The instability in voltage also minimizes the PQ in grid-connected systems. The impacts of improper battery scheduling, unbalanced power flow, and lower system stability affect the PQ of the system.

On the other hand, below are the factor affecting the system in optimum EV charging:

- Reactive power compensation is important for improving the power flow
- Power Quality in Grid-connected System
- Poor Stability has become more challenging which exists in the large-scale implementation of the EV.
- The higher cost is also a big fact which is affecting the stability of implementation in the system.
- Voltage deviation and harmonics
- The right method of EV Charging station which is become now big constraint in the present system.

Several methods have been developed to improve the system stability in grid-integrated EVs by minimizing voltage deviation and harmonics. Still, those methods do not satisfy all the grid-connected EV charging station constraints.

From the literature, it has been observed that the system stability and power flow are enhanced by adding appropriate controllers. However, an efficient system model that considers all the objectives is still an unsolved issue. This encourages us to improve the stability and PQ of SPV-assisted EV charging stations.

4. OBJECTIVES

- To optimize the power extracted from SPV using MPPT controller to ensure the required power to the EV charging station.
- To control the energy flow in the SPV connected EV charging station through an efficient battery scheduling approach
- To enhance the system stability in the grid and SPV connected system supporting EV charging stations using optimized controllers.
- To improve the power quality (PQ) in grid and SPV connected EV charging stations using STATCOM.

5. PROPOSED METHODOLOGY

- ***Method for improving power tracking and battery control***

This work uses solar photovoltaic (SPV) for power generation owing to its reduced emission and installation cost. The power generated by SPV is inherently variable; thus ***hybrid leader optimized*** (Dehghani, Trojovsky 2022) maximum power point tracking ***(MPPT) controller*** is proposed for mining peak power from SPV to deliver consistent power. Here, the MPPT controller provides an optimum duty cycle to the converter to boost the SPV power based on its irradiance level. The photovoltaic voltage and current are fed into the MPPT controller to examine the SPV's peak power. By examining power from SPV, the controller generates an optimum duty cycle. The extracted maximum available power from this controller is given to the battery. The battery is operated as an ESS to avoid the large penetration of PV into the grid by storing the excess energy and also supplying the energy when it is required. Although in previous studies HLBO approach with a stochastic-based algorithm is used and also those studies indicate that another best algorithm can be taken further research as no presupposition for the effective performance.

Moreover, the battery charging and discharging are controlled by ***self-tuned fractional order proportional resonant (FOPR) controller.*** The FOPR controller had the advantage of wider bandwidth than the integral order controller. The FOPR controller examines the optimum scheduling of the battery by considering SOC. The estimated SOC and reference SOC of the battery is given as input to the ***enhanced chimp optimization***

algorithm (Jia, Sun, Zhang, Leng 2022) that generates optimum controlling parameters of the battery based on the minimum error function. EChOA with the multilayer perceptron will resolve the set parameter tuning problems.

The major area of this objective work is given as follows,

- To improve the power extraction from SPV during lower irradiance using the hybrid leader-optimized MPPT controller.
- To enhance the optimum scheduling of the lithium-ion battery through a self-tuned FOPR controller.
- To optimize the controlling parameters of the FOPID controller by enhanced chimp optimization algorithm (ECOA).

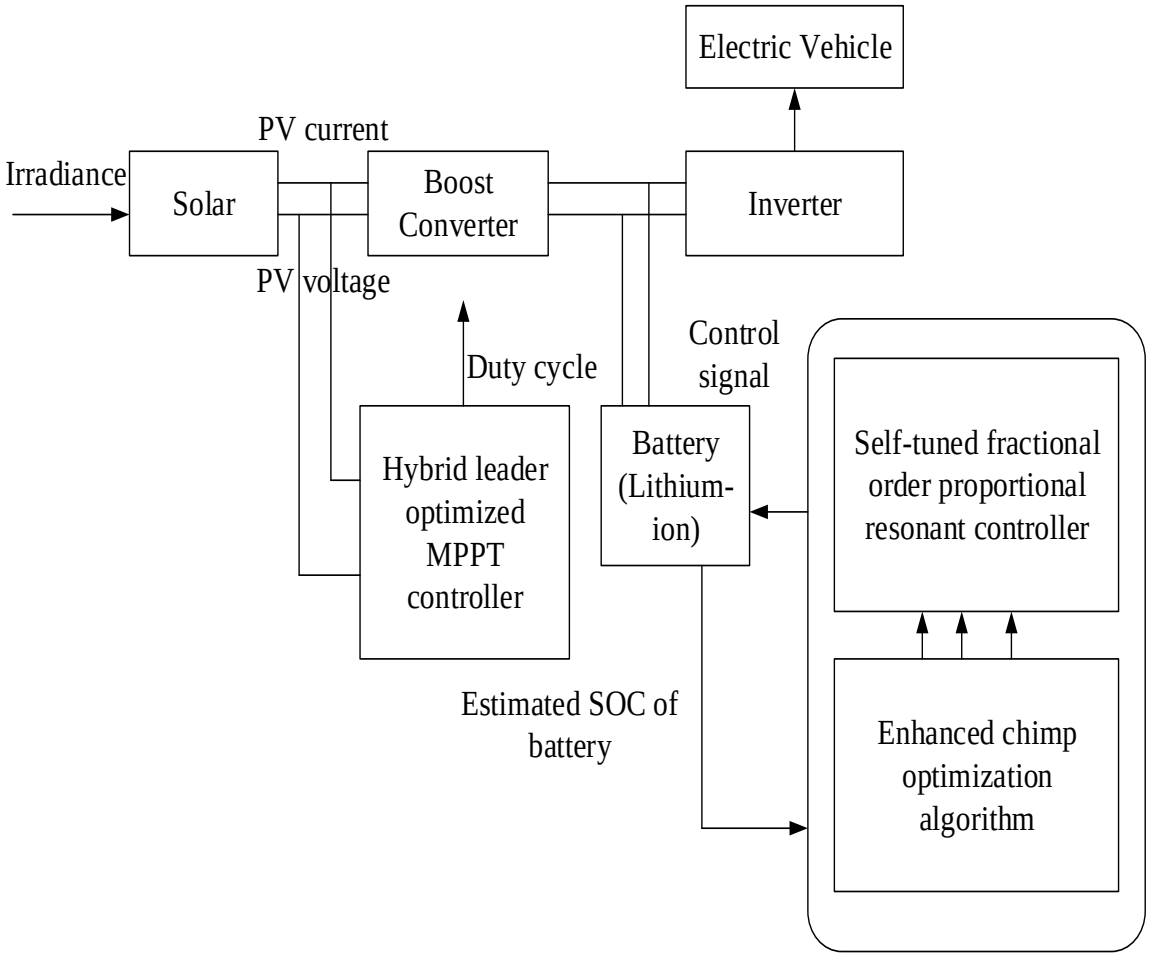

Figure 2: Flow Chart of Battery Control with Power Tracking (Source: Self)

➢ ***A method for power flow management in grid-interfaced batteries***

The uncontrolled charging (UC) and discharging of the battery will reduce the lifespan. Thus, it affects the system's performance. Hence, in this work, the ***sharing knowledge-based optimization algorithm (GSK)*** (Agrawal, Ganesh, and Mohamed 2021) is proposed to alleviate the adverse effect of UC of EV. The prime concern of this method is to reduce the electricity cost, thereby saving the excess energy from the SPV. The formulation-optimized battery scheduling algorithm requires prior knowledge of RES generation. To accomplish this, the ***bi-directional long-term memory (Bi-LSTM)*** neural network is used. The Bi-LSTM can learn large amounts of data that have been trained by traversing the input data in both directions. Also in comparison with metaheuristic algorithms, this is the best algorithm for an optimal solution for quality and ability.

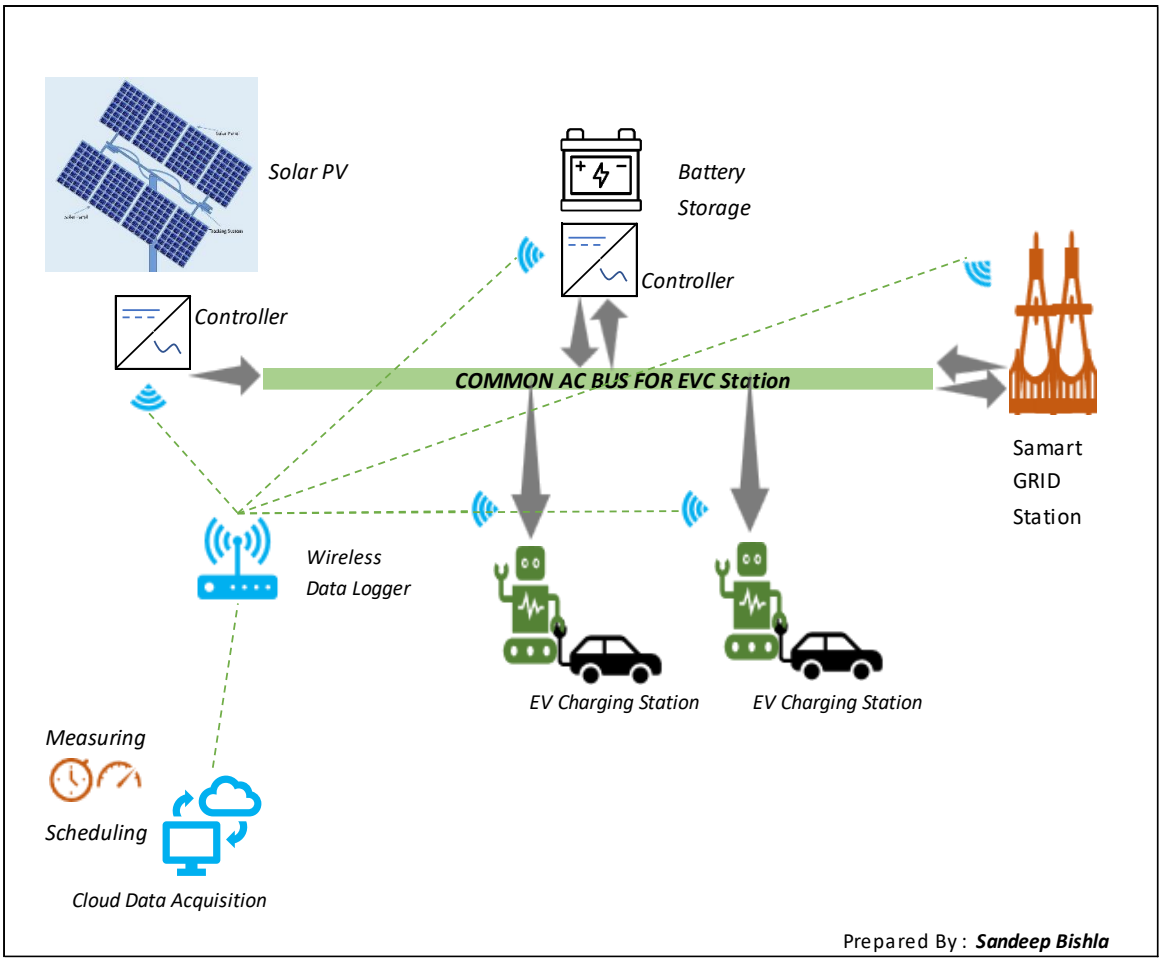

Figure 3: Typical Block Diagram of Electric Vehicle Charging Station connected with Solar PV station, Smart GRID station and showing Battery Storage system connected with common bus supplying to EVC Station. (Source; Self)

- ***An efficient approach towards stability enhancement & Power quality (PQ) improvement through reactive power compensation***

The integration of SPV into EV charging stations satisfies the load demand. However, the integration of SPV in charging stations requires efficient control designs to meet the escalating power demand. Therefore, an optimized controller is proposed for enhancing the integration of SPV with the grid. An auction-based optimization algorithm is employed to heighten the controlling parameters of the adaptive neuro-fuzzy interface system controller, which provides an efficient switching operation to the inverter (Jaddi and Abdullah 2021). These controller regulates the voltage and current to the inverter, thereby facilitating the integration of SPV with the charging station. Moreover, the below proposed controller minimizes uncertainties in the generation and distribution side of the system, which is better or having similar characterstics from the above controller which was using.

By below algorithm we can take the best solution from the best available source to stay connected with the EVC station in live condition, also if any two sources are available the best solution or say with the best suitable parameter will be selected to supply to the EVC station. ABOA techniques work as their named nature, so the best available source supply is selected which will comply with all set parameters for EVC station and on which schedule time when another source is not available, therefore according to the condition null hypothesis can be rejected by this algorithm.

The STATCOM is used for enhancing the PQ of grid-connected EV charging. The optimized ANFIS controller is used for regulating reactive power flow. The STATCOM is widely used to compensate for reactive power in systems with unbalanced and nonlinear loads. Integration of photovoltaic (PV) based electric vehicle (EV) are increased to meet the bulk power requirements with limited dependence from power grid. The grid experienced a power quality (PQ) and stability issues in the distribution system components.

Particularly, during the peak hours it is unable to keep the stability owing to the random power generation from solar. The EV and solar PV must be connected to the grid in a proper manner to improve the power flow. Thus, more attention will be paid for the power electronics components and its controlling. In order to provide the required switching pulses for STATCOM & to accomplish these goals, the ***fuzzy fractional order proportional integral derivative controller (FOPID)*** controlled STATCOM is used in this work. This

approach is far better than a conventional PID controller, and also very efficient in variations in variation with the load which is within the reference environment.

Here, the charging of EV is controlled by ***honey badger optimization algorithm (HBOA)*** (Hashim, Houssein, Hussain, Mabrouk, Al-Atabany 2022). The proposed ***fuzzy FOPID*** controller minimizes harmonics in the system, thereby improving the PQ and improves the system stability by providing control signals to the STATCOM. Here, the three phase signals from the inverter output is given to the STATCOM to compensate the active and reactive power based on the control signals. In the search mechanism, the exploration and exploitation properties are balanced by the solution update process by this algorithm. This HBA algorithm help to avoid the suboptimal regions. The study also gives as an idea, of solving the problem of real-scale optimization.

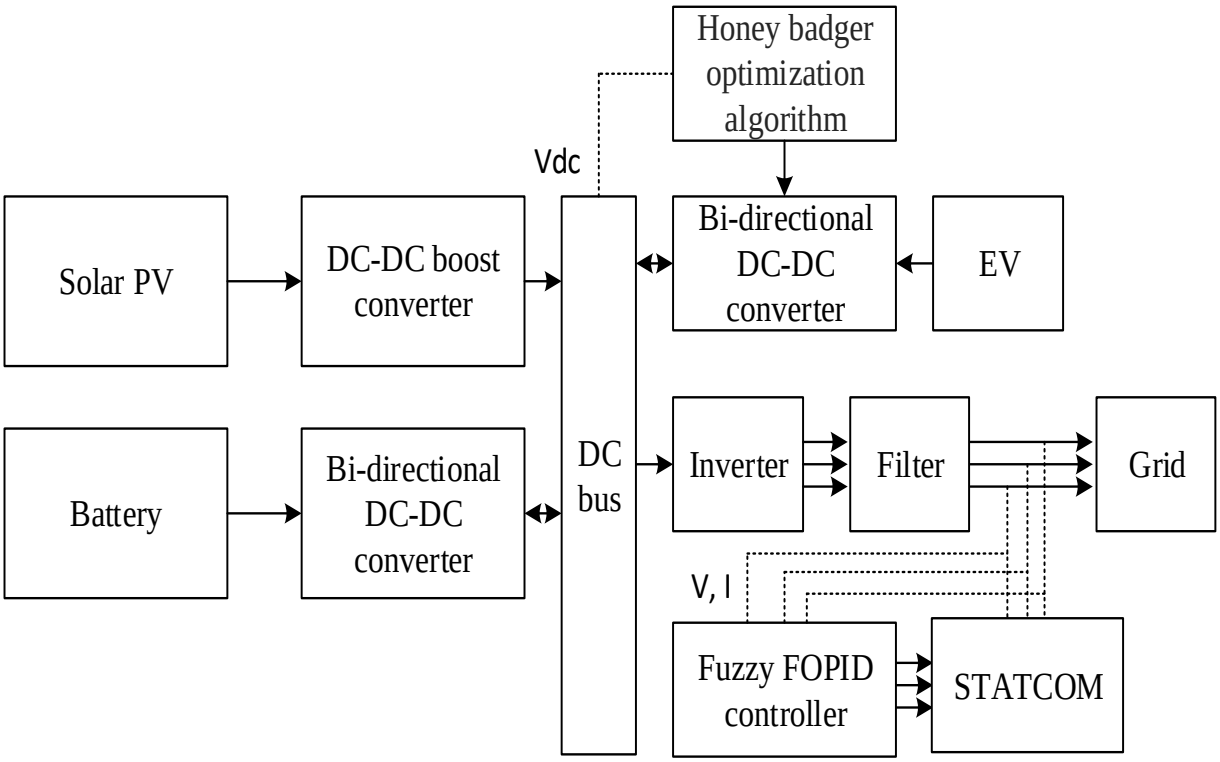

Figure 4: Outline of the work

The major area of this objective work is given as follows,

- Stability enhancement in EV connected system
- Using STATCOM compensate the active and reactive power in system
- PQ enhancement through reactive power compensation

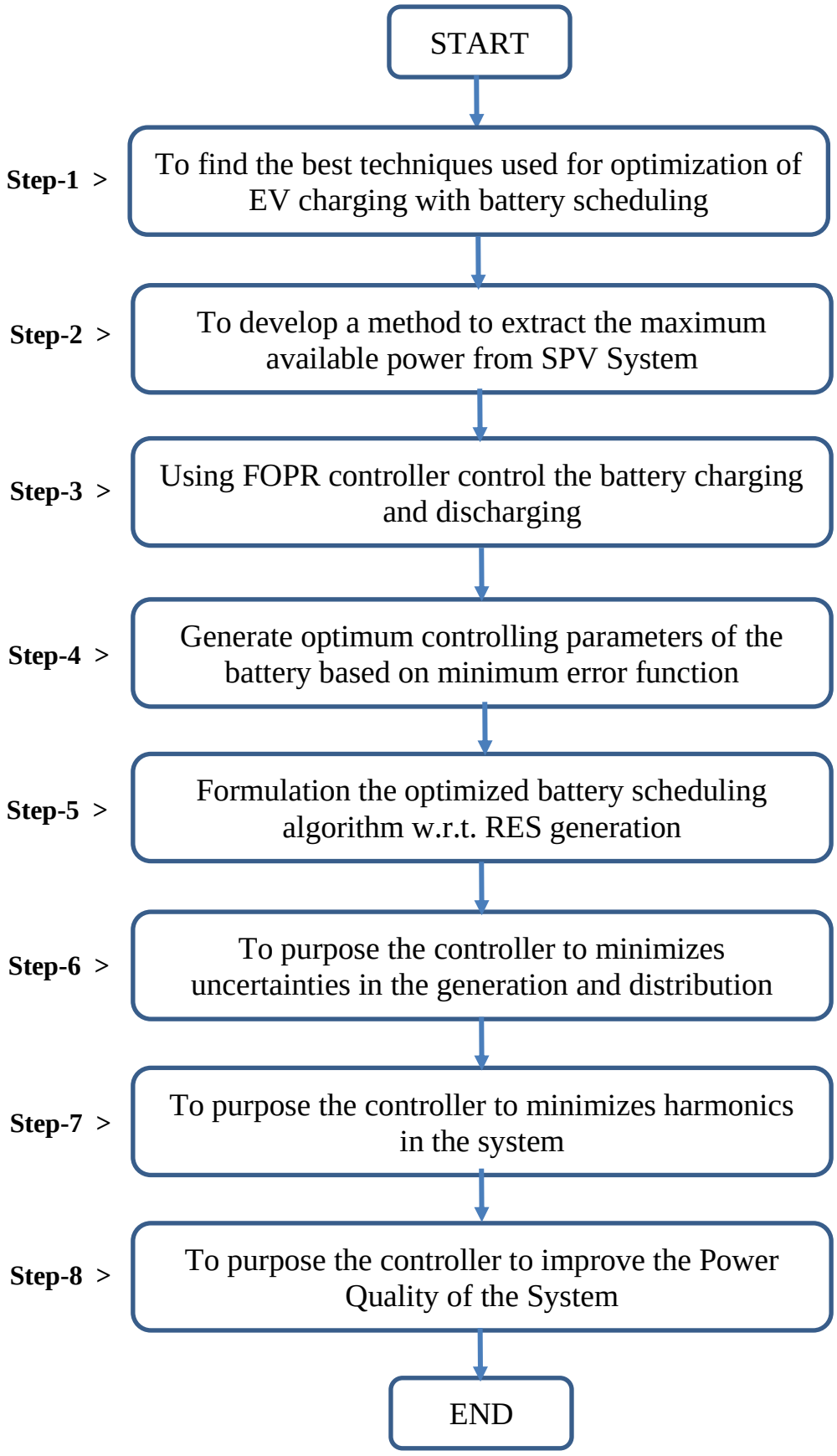
START
Step-1 >
To find the best techniques used for optimization of EV charging with battery scheduling
Step-2 >
To develop a method to extract the maximum available power from SPV System
Step-3 >
Using FOPR controller control the battery charging and discharging
Step-4 >
Generate optimum controlling parameters of the battery based on minimum error function
Step-5 >
Formulation the optimized battery scheduling algorithm w.r.t. RES generation
Step-6 >
To purpose the controller to minimizes uncertainties in the generation and distribution
Step-7 >
To purpose the controller to minimizes harmonics in the system
Step-8 >
To purpose the controller to improve the Power Quality of the System
END

Figure 5: Proposed Methodology

Step 1: To study the existing literature and research about using the different techniques as well as different types of controllers used in the field of EV charging connected with Grid and SPV.

Step 2: To develop a method to extract the maximum available power from SPV System using the hybrid leader-optimized MPPT controller using to extract the maximum power from SPV with consistency in delivery. This controller also helps the system to provide an optimum duty cycle to boost the SPV power.

Step 3: Use FOPR controller to control the battery charging and discharging as it has the advantage of the widest bandwidth. Considering SOC it will examine the optimum scheduling of the storage battery.

Step 4: Generate optimum controlling parameters of the battery based on minimum error function to save the lifespan due to uncontrolled charging and discharging of the batteries, so here we will use GSK algorithm to alleviate the adverse effect of UC of EV.

Step 5: Formulation of the optimized battery scheduling algorithm concerning RES generation, to achieve, using a neural network with Bi-LATM technique as it traverses the input data in either way and can learn a large amount of data also.

Step 6: To purpose the controller to minimise uncertainties in the generation and distribution to maintain/enhance the stability in the system. For the integration of SPV with the grid, an optimized controller is proposed as an enhancement. Here using ANFIS controller for the inverter for efficient switching operation.

Step 7: To purpose the controller to minimise harmonics in the system using honey badger optimized algorithm which controls the parameters. Also for reactive power flow ANFIS controller is used.

Step 8: To purpose the controller to improve the Power Quality of the System using STATCOM in grid-connected EV charging, so accurate and required switching pulse for STATCOM the fuzzy fractional order proportional derivative controller (FOPID) is used to propose.

6. EXPECTED OUTCOME

This research methodology will be implemented on either ***MATLAB (or) Simulink*** platform, and the results will be taken in terms of PV power, tracked peak power, battery SOC, voltage profile, total harmonics distortion (THD), real power loss and reactive power with minimized costs.

The objective-wise outcome is expected in the below form of output quantity:

- Time vs Magnitude
- Frequency vs Magnitude
- Total Harmonics Distortion
- Execution Time
- THD
- Root Means Square
- Fuel Cost
- Demand vs Time
- Total Power
- Power Loss
- Safe of Charge
- Power Dissipation
- Power Consumption
- Charging Time
- Discharging Time

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ABSTRACT

Currently, the modern world switches over to electric vehicles (EV) owing to the environmental hazards in fossil fuels. The EV are influence on the battery operation that is energized by power-generating units. The solar photovoltaic (SPV) system is one of the most promising renewable energy sources for future power generation systems. SPV-connected EV charging is an emerging technology due to the reduction of cost and emissions. However, several factors must be considered while interacting with the SPV with the EV. One of the important issues in SPV is power shortage due to the cyclical disparities in solar irradiance. In order to meet the power requirement from the EV, the maximum power point tracking (MPPT) controllers are adopted with the SPV. The integration of EV chargers with the SPV and grid has brought some impacts on the

system such as an increment in reactive power and power losses. Due to these impacts, the power system stability will be reduced, it also affects the power flow to the EV system. On the other hand, the excess power generation from the photovoltaic model may increase the voltage issues in the EV. Thus, the power supply to the EV is controlled by the battery management system (BMS). The modelling of efficient controllers for battery control will reduce the power unbalancing in the EV system. Moreover, the power flow can be controlled by meta-heuristic algorithms. Furthermore, the integration of EV in the distribution system injects the harmonics in the system hence, the power quality (PQ) gets reduced. The impacts of improper battery scheduling, unbalanced power flow and lower system stability affect the PQ of the system. On the other hand, reactive power compensation is an important area for improving the power flow as well as PQ in the grid-connected system. By concerning all these factors, this research has proposed different approaches to adopt with the different system conditions. This research will bring an effective way to enhance power generation and an optimum solution to feed the EV based on its requirement.

Keywords: Electric Vehicle, EV Charging Station, EV Charger, Smart Grid, Photovoltaic, PV, Grid, Power Quality

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